(12) UK Patent Application (19) GB (11) 2 001 391 A

(21) Application No. 7828482
(22) Date of filing 30 Jun 1978
(23) Claims filed 39 Jun 1978
(30) Priority data
(31) 29341/77
(32) 13 Jul 1977
(33) United Kingdom (GB)
(43) Application published
31 Jan 1979
(51) INT CL²
F02C 7/04 //
F02K 3/04
(52) Domestic classification
F1G 11
F1J 2A1A
(56) Documents cited
GB 1490923
GB 1464971
GB 1462271
GB 1456302
(58) Field of search
F1G
F1J
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(54) **Gas turbine engine air intakes**

(57) A gas turbine aeroengine has an air intake 19 which is deisgned to be subchoked at a certain known troublesome noise-producing condition, the intake being provided with an extended throat region L whose walls comprise, at least in part, sound attenuating linings 27, 29 of the resonant cavity or bulk absorber type.

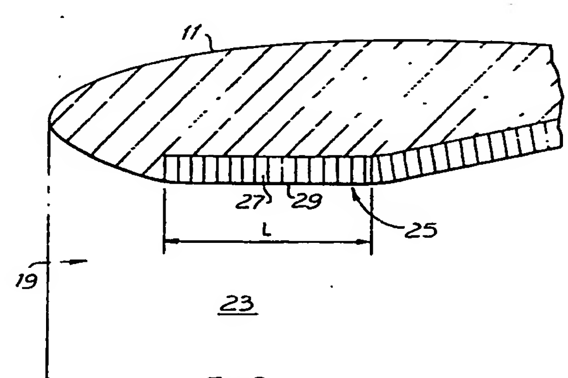

Fig 2

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1 Sheet
Original

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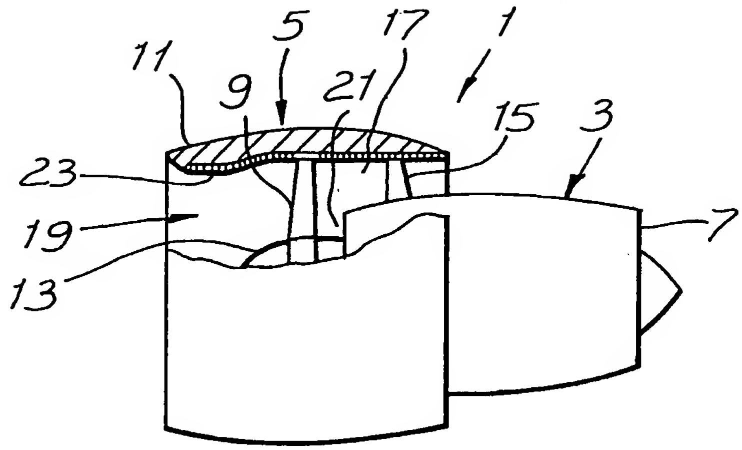

Fig.1

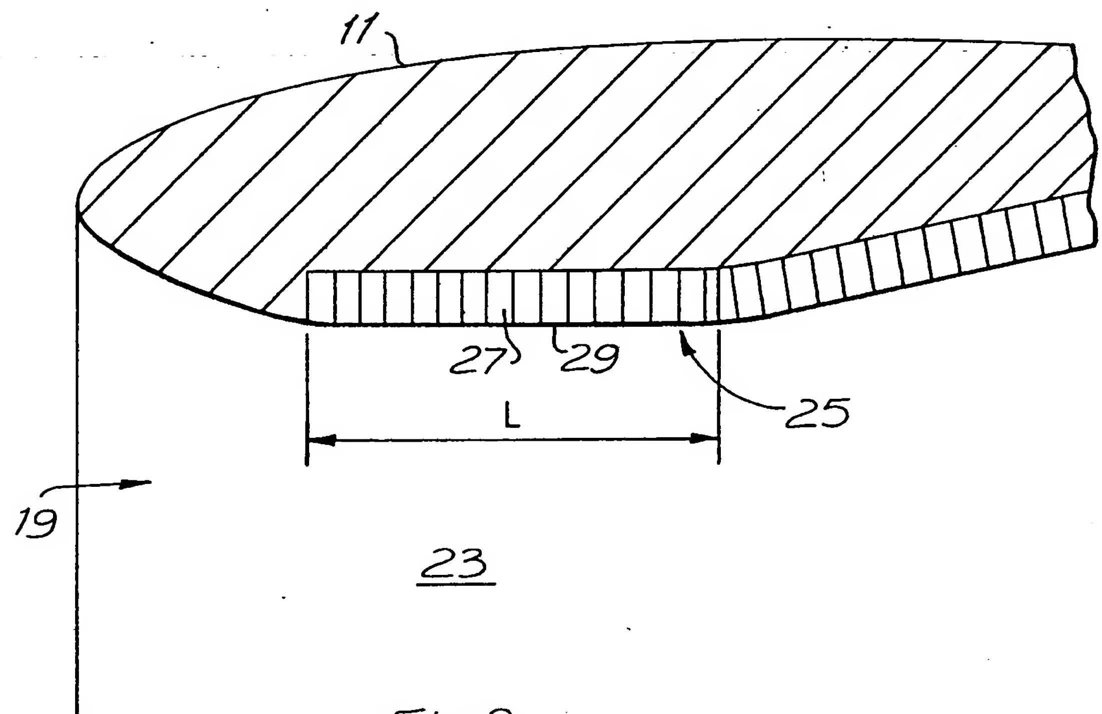

Fig.2

SPECIFICATION

Intakes for gas turbine aeroengines

This invention relates to gas turbine aero-engines having air intake ducts which inhibit the forward propagation of compressor or fan-induced noise within the ducts, and which therefore reduce emission of noise from the mouth of the ducts.

It is known to inhibit forward propagation of compressor or fan-induced noise within the intakes of ducts of gas turbines aero-engines by providing a throat in the intake so that the airflow through it is choked in that region, i.e. the velocity of the flow through the throat is sonic towards the compressor or fan. The area of sonic flow acts as a barrier to noise originating from the downstream direction, since in that area the velocity of the airflow is equal to the velocity of the noise which propagates upstream from the compressor or fan.

Since aero-engines are noisiest on take-off and landing, attempts have been made to design engine intakes so that during normal flights choking of the intake occurs only at these noise sensitive conditions. Unfortunately, the provision of a choking throat which is a permanent part of the internal wall profile of the intake is not desirable for safety reasons because it does not allow sufficient airflow through the intake at certain other conditions of operation which may arise in exceptional circumstances. As a solution to this problem it has been proposed that the throat be provided only as required during the noise sensitive condition by utilising various forms of variable geometry mechanisms in the intake wall, for example, inflatable diaphragms. Thus, during the rest of the flight, or in an emergency, the intake wall can assume a non-choking profile. Nevertheless, in spite of the advantages to be gained in noise reduction, such variable geometry intakes have not been adopted as part of production engines because of the extra weight, cost, and design complication involved.

U.K. Patent Number 1464971 proposed a solution to the above problems on the basis that it is possible to provide an intake with an extended throat region having a substantially constant cross-sectional area over an axial length of the intake in which, during the noise sensitive condition, the airflow is subchoked (i.e. its speed is less than Mach 1). Such an intake will herein be termed a "subchoked intake" for convenience. A subchoked intake allows a margin of safety in case of greater airflow requirements, and yet by virtue of the extended length of the region of subchoked flow, it is said to provide sound attenuating characteristics which are equivalent to a totally choked intake.

Nevertheless, it is indisputable that if the velocity of airflow through the extended throat region is less than sonic, the forward propagation of engine noise through that region will not be totally prevented, since the noise will still have a velocity in the upstream direction (relative to the intake wall). Although the velocity of propagation of the noise is slowed relative to the wall, and the natural attenuation of the noise in the throat region is therefore greater than would be the case for the currently operational type of minimally throated intake, some noise will inevitably propagate to the intake mouth and beyond. It is therefore desirable to reduce forward propagation of noise towards the intake mouth even further, whilst still maintaining subchoked flow in an extended throat region of the intake.

According to the present invention, a gas turbine aero-engine has a subchoked intake, as hereinbefore defined, in which the walls of the extended throat region comprise, at least in part, sound attenuating linings of the resonant cavity or bulk absorber type.

The velocity of propagation of noise in the upstream direction relative to the sound attenuating lining is substantially slower than the speed of sound in the extended throat region, and the lining is thus very effective at attenuating the noise present in the throat; because sound waves or shock waves take longer to transverse the extended throat region than they would to transverse the same distance in an intake not provided with an extended throat region, relatively more of them are intercepted by the lining and attenuated by resonance and/or absorption in the lining.

Because of the high velocity of the flow in the extended throat region, the walls, of the throat are preferably substantially aerodynamically smooth to avoid inducing turbulence and noise due to edge effects. Thus although perforated sheets may be used as sound permeable facings for the sound attenuating liners, it is preferred that such facings comprise materials which, although permeable to sound, have a smooth unbroken surface. Examples of suitable facings could be: a finely woven resin bonded and coated glass fibre cloth; or, non-woven bonded cloths made from fine strands of resin-coated glass fibre or fine strands of wire compressed and sintered together.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which :–

Figure 1 shows diagramatically a high by-pass ratio gas turbine aero-engine incorporating a subchoked intake according to the invention.

Figure 2 shows an enlarged view of Figure 1.

Referring to Figure 1, a high by-pass ratio gas turbine aeroengine 1 comprises a core engine 3 and a ducted fan propulsor 5. As is well known, a core engine such as core engine 3 incorporates compressor, combustor, turbine and core jet propulsion nozzle sections, only the core jet propulsion nozzle 7 being rereferenced in the Figure. The ducted fan propulsor 5 is shown in partial section and includes: a fan 9, which is driven via a shaft (not shown) from a low-pressure turbine in the core engine 3; a fan duct casing structure 11 which surrounds the fan 9 and is coaxial with the core engine 3, but is spaced radially outwards from it; and an aerodynamic nose bullet 13 associated with fan 9, Duct casing 11 is supported from core engine 3 via struts 15, which form outlet guide vanes for the flow of by-pass air though the annular by-pass duct 17, whose bounding walls are the internal periphery of duct casing 11 and the external periphery of the core engine 3. During operation of the engine 1, air enters intake 19 of engine 1,

is given velocity and pressure increments by fan 9, and the flow is divided at 21 between the core engine 3 and the by-pass duct 17. Intake 19 of the engine 1 is provided with an extended throat region 23 in which, during operation of the engine at certain conditions such as take-off or landing when fan-originating noise is particularly troublesome, the airflow is "sub-choked", i.e. the velocity of the airflow in throat region 23, although substantially greater than that before and after it, nevertheless remains less than the local speed of sound.

REFERRING TO Figure 2, extended throat region 23 has a substantially constant cross-sectional area over an axial length L of the intake 19. Since this cross-sectional area is chosen so that throat region 23 is never choked under normal operating conditions of the engine, there is a margin of safety available should the fan 9 (Figure 1) demand more air in exceptional circumstances.

Noise spirals away from the fan 9 in the upstream direction towards the intake 19, but its velocity relative to the duct casing 11 is reduced by the velocity of the airflow towards fan 9. The airflow has its greatest velocity in throat region 23, and the velocity of the downstream originating noise is therefore at its least value in that region.

Rather than relying merely on natural attenuation of the "slow" noise over the length L to minimise the amount of noise emitted from the mouth of intake 19, the wall of the throat region 23 incorporates a sound attenuating lining 25 of the resonant cavity type, having a honeycomb core 27 and a facing skin 29. Facing skin 29 can take the form of a perforated sheet having a large number of small diameter holes which allow sound energy to enter the lining. However, to avoid turbulence and noise due to the high velocity flow of the air over such holes, it is preferred that facing skin 29 be made of a material which, although permeable to sound, is substantially aerodynamically smooth, i.e. has an effective surface roughness which is of the same order as, or better than, that of the unlined parts of the internal wall of the duct casing structure 11. Such materials have a high resistance to air flow through them, such as finely woven resin bonded glass fibre cloth, or non-woven bonded cloths made from fine strands of resin-coated glass fibres or fine strands of wire compressed and sintered together.

Although the sound attenuating lining just described in relation to Figure 2 is of the resonant cavity type, it should be understood that a lining incorporating bulk noise absorber materials such as glass fibre wool or the like could be used instead of, or in combination with, a resonant cavity lining. This would give sound attenuation over a wider frequency range.

As shown in the present Figures 1 and 2, it is desirable to provide sound attenuating linings over as much as possible of the axial extent of the internal periphery of the fan duct casing 11.

CLAIMS

1. A gas turbine aeroengine axial flow air intake provided with an extended throat region having a substantially constant cross-sectional area extending over a certain axial length of the intake, the extended throat being adapted to allow airflow therethrough at a velocity which, when the engine operates at a certain known troublesome noise-producing condition, is substantially greater than that upstream and downstream of said throat but which is less than the local speed of sound in said throat, wherein the walls of said throat comprise, at least in part, sound attenuating linings of the resonant cavity or bulk absorber type.

2. An air intake according to claim 1 in which the sound attenuating linings in the extended throat region have a sound permeable facing with a substantially unbroken surface.

3. An air intake according to claim 1 or claim 2 in which the sound permeable facing comprises a finely woven resin bonded and coated cloth of a suitable material, or a non-woven bonded cloth made from fine strangs of a suitable material.

4. A gas turbine aeroengine axial flow air intake substantially as described in this specification with reference to and as illustrated by the accompanying drawings.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon Surrey, 1978.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.